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(54) Knittable yam and safety apparel.

(57) Yarn and a knitted safety glove or other article made of the yarn (13), which has a core (10) of at least one strand (20) of high strength liquid crystal polymer fiber such as Vectran HS fiber surrounded by one (12) or two (12,14) wrappings of high strength synthetic fiber, preferably high strength liquid crystal polymer fiber such as Vectran HS fiber or high strength aramid fiber, or high strength stretched polyethylene fiber, or a combination of high strength fibers. One embodiment of the yarn includes a wire strand in the core. In one embodiment the fiber core strand (30) is of 200 to 1500 denier and has one to fifty filaments of 4 to 500 denier. In another embodiment, a second high strength synthetic core strand is included.

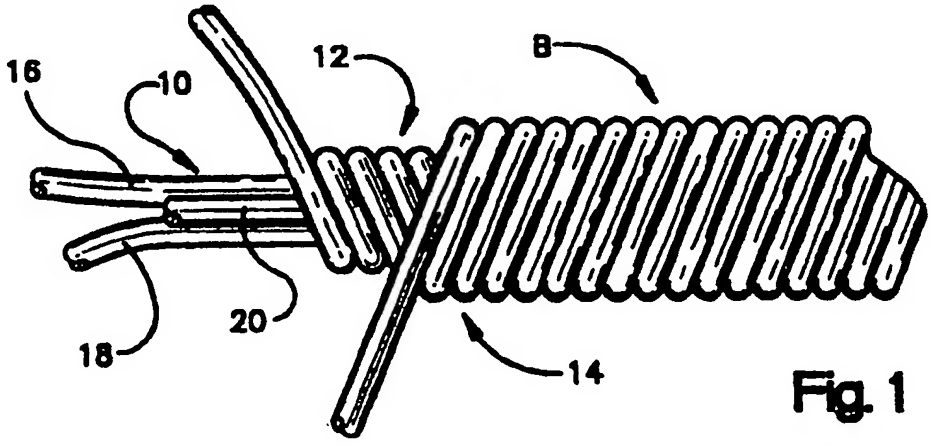

Fig. 1

EP 0 458 343 A1

Technical Field

The invention relates to yarn suitable for machine knitting and to safety garments made with the yarn.

Background Art

Cut-resistant yarn utilizing stainless steel wire strands and high tensile strength aramid strands, such as Kevlar made by E.I Dupont de Nemours Corp., and gloves made therefrom are shown in the Byrnes et al. U. S. Patent No. 4,384,449 and in the Bettcher U. S. Patent No. 4,470,251. These gloves have proven highly successful. One other fiber, a high strength stretched polyethylene fiber manufactured and marketed by Allied Corporation, Morris Township, Morris County, N. J., U.S.A., has heretofore also provided good cut resistance when used in place of aramid fiber. The Allied fiber is sold under the name Spectra and is described in detail in U. S. Patent No. 4,413,110 to Kavesh et al. Other fibers have not provided equal cut resistance along with other desirable characteristics for such products.

Disclosure of the Invention

The present invention provides a high strength, cut-resistant, knittable composite yarn that utilizes a yarn or fiber strand or component, spun from Vectran liquid crystal polymer, of high strength to provide high cut resistance. The yarn or fiber is a high performance filament yarn sold by Hoechst Celanese Corporation, Charlotte, North Carolina, under the name Vectran HS. This yarn or fiber has essentially the same strength as the aramid fiber sold under the name Kevlar, but has better abrasion resistance. At the same time, it has significantly better heat resistance than high strength stretched polyethylene fiber, thus overcoming a different shortcoming of each of Kevlar and Spectra for use in a cut resistant yarn used for apparel and particularly for cut resistant gloves, while providing the substantial advantages that those two materials have over other materials in terms of cut resistance and other characteristics in a composite yarn. Thus, knit fabric suitable for gloves and other safety garments utilizing Vectran HS fiber has greater abrasion resistance than similar fabric made with aramid fiber or a combination of aramid and nylon fiber, yet is itself nonabrasive and comfortable to wear, and such fabric can be laundered at high temperatures conventionally used for industrial fabrics without degrading the fabric.

In its broad aspects, the present invention provides a cut-resistant yarn suitable for machine knitting, comprising a core having at least one strand of high strength liquid crystal polymer fiber, such as Vectran HS fiber, having an initial tensile modulus of at least 600 grams per denier, and of a denier between about 200 and 1,500; and a wrapping of synthetic fiber wound about the core, the wrapping having a tenacity greater than 10 grams per denier.

In preferred forms, an embodiment of the invention utilizes wire in the core, and another embodiment does not, but instead relies on a limited number of filaments of significant denier to comprise the liquid crystal polymer yarn or fiber of the core.

In their broad aspects, the embodiments of the present invention that utilize wire in the core provide a cut-resistant yarn suitable for machine knitting, comprising a core having at least one strand of flexible metal wire having a diameter of from about 0.002 inch to about 0.010 inch, 0.051 mm to about 0.25 mm, and at least one strand of high strength liquid crystal polymer fiber such as Vectran HS fiber, having an initial tensile modulus of at least 600 grams per denier and of a denier between about 200 and 1,500; and a wrapping of synthetic fiber wound about the core, the wrapping having a tenacity greater than 10 grams per denier and preferably greater than the tenacity or tensile strength of the metal wire. In their broad aspects, the embodiments of the invention that do not utilize wire in the core provide a cut-resistant yarn suitable for machine knitting, comprising a core having a strand of high strength liquid crystal polymer fiber, such as Vectran HS fiber, having an initial tensile modulus of at least 600 grams per denier and a denier of between about 200 and 1,500, and formed of from 1 to 50 filaments, or so-called "ends."

The invention further provides a cut-resistant machine-knitted article of apparel, one such article being a flexible glove, at least in part made of yarn having the constructions as described above.

In preferred constructions, the yarn utilizes either two wrappings of Vectran HS fiber, each of a denier of from about 200 to about 800, which provide high cut resistance, abrasion resistance, and heat resistance; or two wrappings, one of Kevlar or other high strength aramid and one of Spectra or other high strength stretched polyethylene, each of from about 200 to about 800 denier, which provide very high cut resistance. In preferred constructions of the embodiments that do not include wire in the core, the core filaments or ends of the Vectran HS fiber are each between 4 and 500 denier. In such a construction, a strand of another high strength synthetic fiber, such as Spectra or Kevlar, may also be used in the core along with the Vectran HS fiber.

A glove or other article of apparel utilizing a

preferred yarn construction has not only high resistance to cutting, but also good wear qualities and comfort, does not take a set during use, is non-abrasive, provides a good appearance, and is cleanable and long wearing.

The above and other features and advantages of the invention will become more apparent from the detailed description that follows.

Brief Description of the Drawings

Figure 1 is a fragmentary, diagrammatic, view of a yarn embodying the present invention;

Figure 2 is a fragmentary, diagrammatic, view of a second yarn embodying the present invention;

Figure 3 is a fragmentary, diagrammatic, view of a third yarn embodying the present invention; and

Figure 4 is a diagrammatic view of an article of apparel, i.e., a knitted glove, made of yarn embodying the present invention, such as the yarn shown in Figures 1, 2 and 3.

Best Mode for Carrying Out the Invention

The depicted glove A is exemplary of a safety article of apparel embodying the present invention and is a safety or protective glove suitable to be worn by operatives in the food processing and other industries where sharp instruments or articles, such as knives, or material having sharp edges, for example, sheet metal, glass and the like, are handled, and is made of a composite multistrand yarn B, C or D constructed in accordance with the present invention. The glove A has the usual finger and thumb stalls 4, 6 respectively, and a wrist part 8 incorporating an elastic thread or yarn. The glove is made using conventional methods and glove knitting machinery.

The yarn B employed in the glove A comprises a core part 10 and two windings 12, 14 of synthetic fiber wound thereon in opposite directions one on top of the other. The fact that the wrappings 12, 14 are in different directions balances the forces incident to the wrappings so the yarn has no unusual twist or tendency to coil and assists in holding the wrappings in place on the core 10. The windings are between four and twenty turns per inch and preferably about eight to twelve turns per inch. The core part 10 of the yarn B comprises two strands of annealed stainless steel wire 16 and 18, and one strand 20 of Vectran HS fiber, marketed by Hoechst Celanese Corporation. In another preferred embodiment, only one strand of annealed wire identical to the strand 16 is provided in the core.

The core structure 10 is designed to provide cut resistance, knittability, flexibility and life to the yarn; and the wrappings 12, 14 retain the core and create body. One or both of the wrappings 10, 12 are of high strength synthetic fiber to contribute significantly to the cut resistance of the yarn.

The stainless steel wire 16 of the core part of the yarn B has a diameter of about 0.003 inch, 0.076mm. Stainless steel wire of the size mentioned, of 304 stainless steel, fully annealed, which has a tensile strength of about 110,000 to 135,000 pounds per square inch, is believed to have optimum flexibility and life.

The strand of synthetic fiber 20 in the core 10 of the yarn B is a high strength relatively non-stretchable multifilament synthetic fiber of Vectran HS having a tensile strength greater than that of the wire. The Vectran HS liquid crystal polymer fiber has an initial tensile modulus of at least about 600 grams per denier. It has a tenacity (tensile strength at break) of about 20 to 25 grams per denier and its elongation at break is about 2.2 to 2.5 percent. The size of the strand 20 is 900 denier, but other sizes are suitable, from about 200 to about 1,500 denier, more preferably from about 500 to about 1200 denier, and most preferably from about 900 to about 1200 denier.

The first or inner wrapping 12 on the core 10 of the yarn B is a high strength synthetic fiber, preferably a multifilament high strength fiber material, such as Vectran HS is used for the strand 20. Because Vectran HS fiber material has good abrasion resistance and heat resistance along with its cut resistance, it is advantageously used for the outer wrapping 14 as well as for the inner wrapping 12. Thus, in the embodiment shown, the outer wrapping 14 of the yarn B is identical to the inner wrapping 12, except wrapped in the opposite direction. The use of a single high strength fiber material for both wrappings 12 and 14 simplifies inventory and processing procedures and gives improved cut and abrasion resistance over the use of two aramid wrappings or an aramid inner wrapping and a nylon outer wrapping and better heat resistance over the use of two high strength stretched polyethylene wrappings or an inner high strength stretched polyethylene inner wrapping and a nylon outer wrapping. While a polyester outer wrap may be used in place of the outer Vectran HS wrap, a reduction in cut resistance will result. Each wrapping 12 and 14 is of a denier of from about 200 to about 1500, more preferably from about 200 to about 1000, and most preferably from about 200 to about 800. Preferably each wrapping is about 200 denier when the yarn is used for a glove knitted with two strands of the yarn (i.e., two strands of yarn are threaded concurrently through a knitting needle), or when the yarn is used for a lighter weight glove having greater flexibility and comfort. For a glove or protective garment knit from a single strand of yarn and also having very high cut resis-

tance, it is preferred that the inner and outer wrappings be of greater denier, preferably from about 400 to 600 denier. The overall diameter of the yarn B should be no greater than 0.05 inch, 1.27mm and preferably no greater than 0.03 inch, 0.76mm to facilitate machine knitting.

Cut resistance of the yarn B and the glove A when made of the yarn B is in part a function of the quantity of metal wire in the yarn. However, stainless steel core strands in excess of 0.004 inch, 0.102mm in diameter reduce the flexibility and knittability of the yarn and the wearing qualities of garments made of such yarn. Plural steel strands are advantageous for flexibility over one larger strand where increased cut resistance is desired. Two to six stainless steel core strands of about 0.002 inch to about 0.006 inch, 0.051mm to about 0.152mm, in diameter can be employed in typical applications. Stainless steel strands of a diameter less than about 0.002 inch, 0.051mm, have a shorter life, are relatively expensive and have not been found to be otherwise sufficiently advantageous to warrant the increased cost. Stainless steel strands having diameters between about 0.002 inch, 0.051mm, and about 0.004 inch, 0.102mm, have been found to be most satisfactory. Stainless steel is preferred for the wire strands employed in preferred embodiments of the invention and is important for use in gloves and other garments used in the food industry. Other kinds of metal wire strands, if desired for special purposes, may be used, such as, aluminum, copper, bronze or steel.

The use of a multifilament high strength liquid crystal polymer fiber strand, such as Vectran HS fiber strand, in the core is very advantageous. Multifilament strand is very linear and slides and/or flows well relative to the other parts of the core during fabrication and subsequent use of an article of apparel produced therewith. The high strength multifilament core strand, which is relatively unstretchable, takes a great deal if not the major part of the tensile load to which the yarn is subjected during knitting. It also appears to increase the flexibility of the core part of the yarn over an all metal core and in turn makes the yarn more easily knit, i.e., imparts to the yarn greater knittability. It also improves cut resistance. The synthetic wrappings 12, 14 of multifilament high strength liquid crystal polymer fiber such as Vectran HS fiber contribute to the cut resistance of the yarn. The wrapping 12 provides a desirable rigid backup surface for the outer wrapping 14, which tends to fill out the valleys of the wrapping immediately therebeneath. The multifilament wrappings 12, 14 wound flat about the core, producing a yarn with a smooth surface that aids the knitting process and that has a good appearance, a non-abrasive surface, and that provides heat resistance and maximum comfort.

An alternative yarn C employed in the glove A comprises a core 30 and three wrappings 32, 34 and 36 of synthetic fiber about the core, one on top of another and in an opposite direction. The wrappings have between four and twenty turns per inch and preferably about eight to twelve.

The core 30 is a strand of Vectran HS fiber, and has a denier of about 200 to about 1500 and is comprised of from one to 50 filaments or ends, each of which has a denier of from about 4 to about 500. The use of relatively few filaments of relatively high denier, preferably a denier of at least 12 and more preferably at least 20, results in the core strand behaving somewhat like a monofilament core and allows the Vectran HS to function as a replacement for the steel wire in the core, but without the need for another high strength synthetic fiber along with it, as is the case with the wire. Of course, an additional high strength synthetic fiber can be used with it, if desired.

One of the wrappings 32, 34 is a high strength aramid fiber, such as Kevlar, and the other is a high strength stretched polyethylene fiber, such as Spectra. In the embodiment shown, the wrap 32 is Kevlar and the wrap 34 is Spectra. The wraps each have a denier of about 200 to about 1500 and preferably 200 to 800. The use of a combination of Spectra and Kevlar has been found to provide greater strength than when two equivalent sized wraps of only one of the two materials are used. The third and outer wrap 36 is of a soft synthetic fiber, such as polyester or nylon, having a denier of about 200 to about 1000. The diameter of the yarn C is between about 0.01 and about 0.05 inch, 0.25mm and about 1.27mm and preferably no greater than 0.03 inch, 0.76mm.

A construction D is shown in Figure 3, which is identical to the construction C shown in Figure 2 (identical parts being identified with identical reference numerals, but with a prime) except that an additional core strand 36 of high strength stretched polyethylene, such as Spectra, or high strength aramid, such as Kevlar, of 200 to 1200 denier is provided.

The depicted glove A is a safety glove especially advantageous for use in the food processing industries and is highly cut resistant, abrasive resistant, readily cleanable at high temperatures, comfortable to wear, nice appearing, flexible and relatively non-absorbent. The last characteristic of the glove is very important in the food processing industries. The glove is also chemical, abrasive and fatigue resistant, is also resistant to the transfer of heat or cold, is conformable, does not acquire a set during use, is non-shrinkable, is light in weight, and provides a secure grip.

Gloves knit from yarn described above using

high strength liquid crystal polymer fibers, such as Vectran HS fibers, provide increased cut resistance over yarn that utilizes comparable quantities of aramid fiber and provide improved abrasion resistance. Wash and dry tests show it has substantially less shrinkage than high strength stretched polyethylene.

While the yarn of the invention has been described and shown incorporated into a knit safety glove, it is to be understood that the yarn of the present invention can be used to make other fabrics and articles of apparel, safety or otherwise, such as wrist guards, protective sleeves, gaiters, safety aprons, etc. for use in the meat processing and other industries.

While variations in certain of the materials and sizes of the strands employed in preferred embodiments of the invention herein described can be made, the preferred embodiments of the yarn of the present invention are believed to produce the optimum balance between strength, resistance to cutting, resistance to heat, appearance, comfort, knittability, wearability, cleanability, and cost.

From the foregoing description of preferred embodiments of the invention it will be apparent that the advantages of the invention heretofore enumerated and others have been accomplished and that there have been provided an improved knittable yarn and safety articles of apparel made therewith having superior qualities. While preferred embodiments of the invention have been described in considerable detail, various modifications or alterations may be made therein without departing from the spirit or scope of the invention set forth in the appended claims.

Claims

1. In a cut-resistant yarn suitable for machine knitting including a core having high strength synthetic fiber and a wrapping of synthetic fiber about the core, the wrapping having a tenacity greater than 10 grams per denier; the improvement wherein the said core fiber is a high strength liquid crystal polymer having an initial tensile modulus of at least 600 grams per denier and a denier of about 200 to 1500.

2. A cut-resistant yarn as set forth in Claim 1 further including an additional wrapping of synthetic fiber, the wrapping strands having a denier of about 200 to 1000 and a tensile strength greater than 110,000 pounds per square inch and wherein the core fiber comprises no more than 50 filaments.

3. A cut-resistant yarn as set forth in Claim 1 having three wrappings, one being a high strength aramid fiber having a denier of about 200 to 1500, another being a high strength stretched polyethylene fiber having a denier of about 200 to 1500, and an outer wrapping of a synthetic fiber having a denier of about 200 to 1000, and wherein the overall diameter of the yarn is no greater than 0.05 inch.

4. A cut-resistant yarn as set forth in claim 1 wherein the core includes a flexible metal wire having a diameter between 0.051 millimeters to 0.254 millimeters the improvement further characterized in that said wrapping of synthetic fiber is a high strength liquid crystal polymer fiber having a denier of about 200 to 1200.

5. A cut-resistant yarn as set forth in Claim 4 further including a second wrapping of high strength liquid crystal polymer fiber and wherein both wrappings have an initial tensile modulus of at least 600 grams per denier.

6. A cut-resistant glove as set forth in Claim 4 wherein the core comprises at least two and no more than six strands of fully annealed stainless steel wire having a diameter of from about 0.051 millimeter to about 0.152 millimeter.

7. A cut-resistant glove as set forth in Claim 4 wherein the overall diameter of the yarn is no greater than 1.27 millimeter.

8. A cut-resistant yarn as set forth in claim 4 wherein the high strength liquid crystal polymer fiber of the core has an initial tensile modulus of at least 600 grams per denier and a denier of about 900 to 1200, and there are two wrappings of synthetic fiber wound about the core, one wrapping being a high strength liquid crystal polymer fiber having an initial tensile modulus of at least 600 grams per denier and a denier of between about 200 to 800, and the overall diameter of the yarn being no greater than 1.27 millimeters.

9. A cut-resistant article of apparel knitted from the yarn as set forth in any one of Claims 1-8.

10. A cut-resistant glove knitted from the yarn as set forth in any of Claims 1-8.

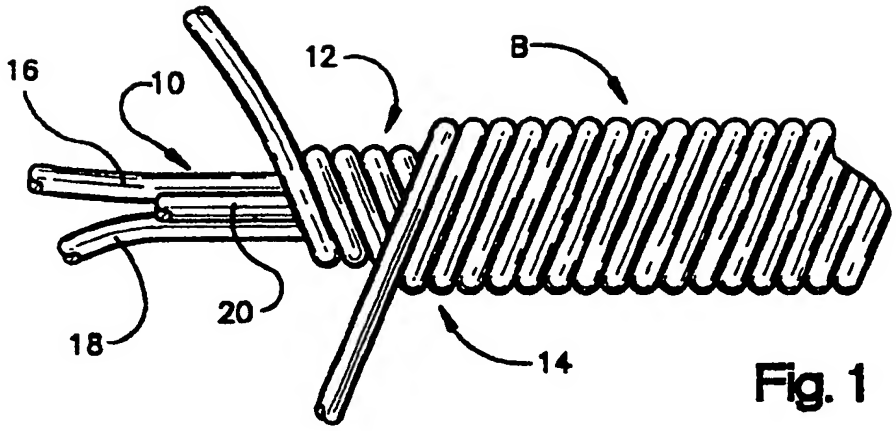

Fig. 1

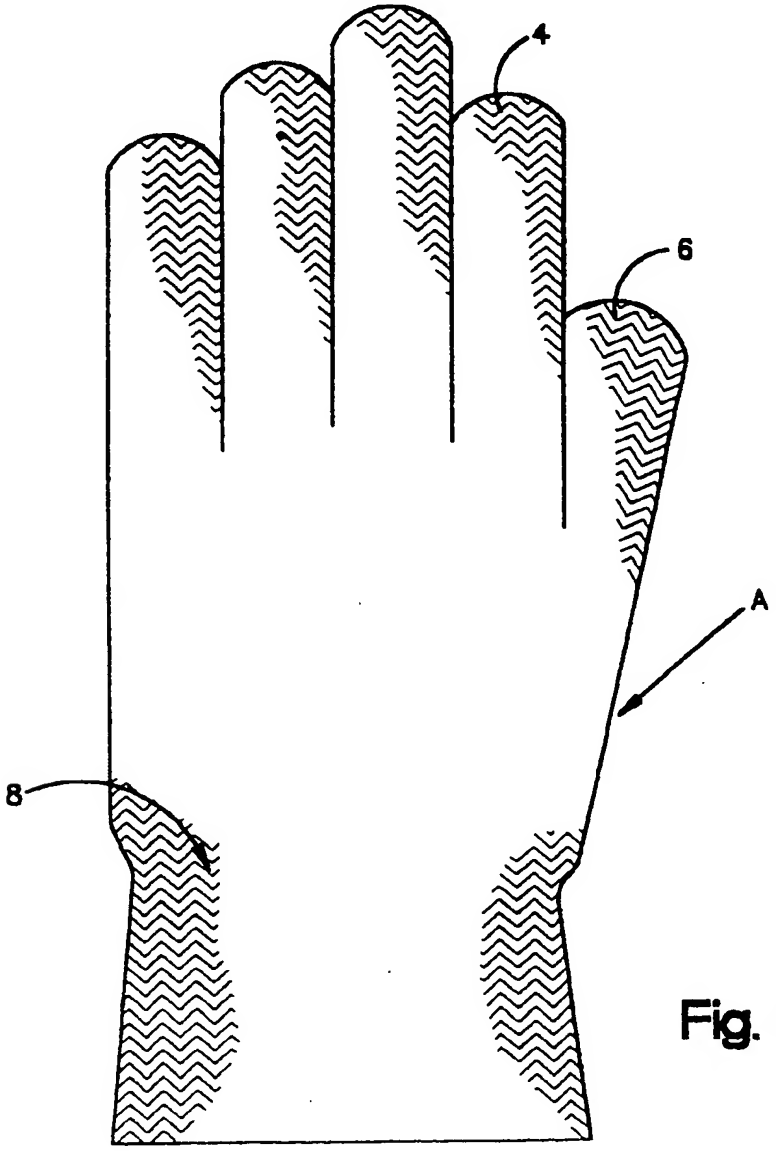

Fig. 4

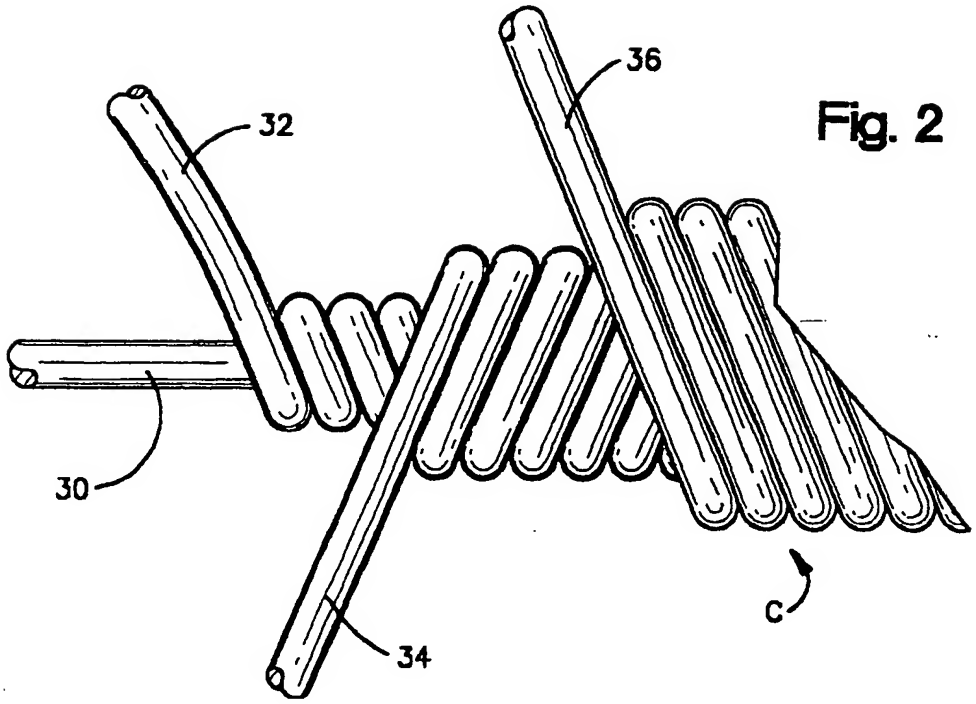

Fig. 2

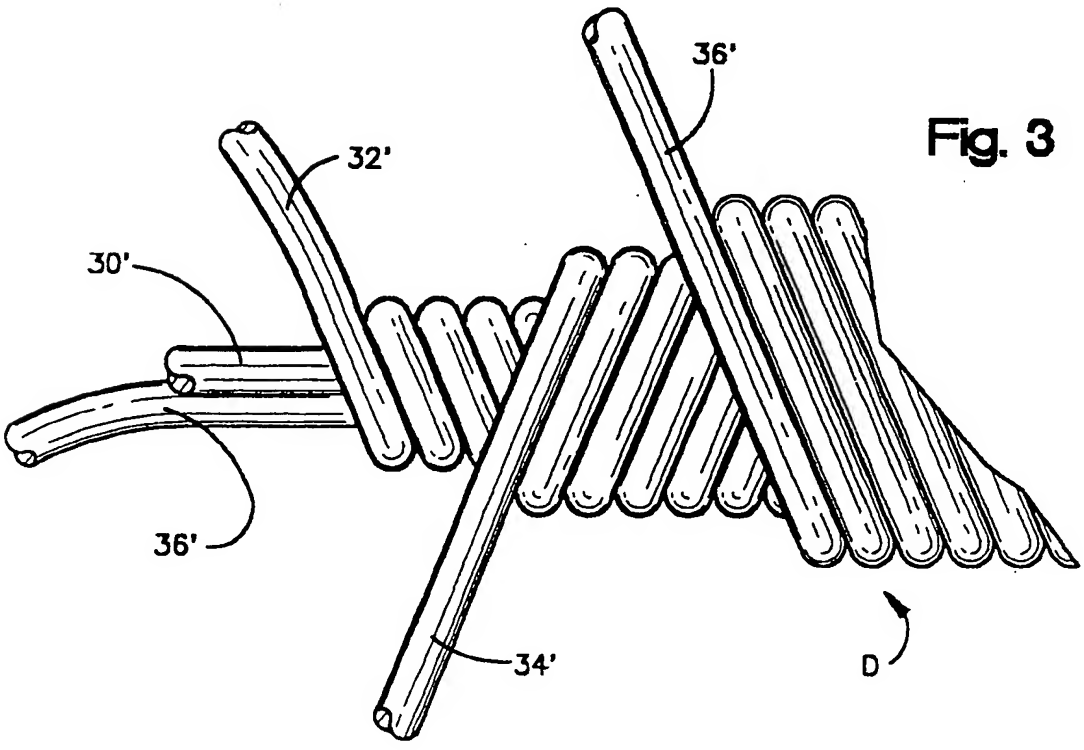

Fig. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 10 8381

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 912 781 (ROBINS ET AL) * column 3, line 23 - line 46; claims 3,5,8,9; figures 2-4 *	1,2,7-10	D 02 G 3/12 D 02 G 3/44 A 41 D 31/00
A,D	US-A-4 470 251 (BETTCHER) * column 2, line 44 - column 3, line 34 * * column 3, line 49 - column 4, line 48; figures 1-3 *	1-4,6-10	A 41 D 13/10
A,D	US-A-4 384 449 (BYRNES SR ET AL) * claims 1-5,11-31; figures 1,2 *	1-10	
A,D	US-A-4 413 110 (KAVESH ET AL) * abstract *	1-3	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
D 02 G A 41 D D 07 B

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	04 September 91	TAMME H.-M.N.

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